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APPROVAL STANDARD

FOR

EXPLOSIONPROOF ELECTRICAL EQUIPMENT

GENERAL REQUIREMENTS

Class Number 3615

March 1989

EFFECTIVE DATE: JANUARY 1, 1992

Factory Mutual System

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Class No. 3615 March 1989

APPROVAL STANDARD FOR EXPLOSIONPROOF ELECTRICAL EQUIPMENT GENERAL REQUIREMENTS

I INTRODUCTION

1.1 PURPOSE

This standard serves as the basis for Factory Mutual Research Corporation (FMRC) Approval of explosionproof electrical equipment.

1.2 SCOPE

This standard contains the basic requirements for the construction and testing of explosionproof electrical equipment. This standard is intended to be used in conjunction with Class 3600 Approval Standard which includes the general requirements that apply to all types of hazardous (classified) location protection methods and the following Approval Standards which include the additional construction and testing requirements for the listed specific categories:

Class 3615.10 - Outlet Boxes and Fittings (Proposed)
Class 3615.20 - Motors and Generators (Proposed)
Class 3615.30 - Industrial Control Equipment (Proposed)
Class 3615.40 - Process Control Equipment (Proposed)
Class 3615.50 - Electric Lighting Fixtures (Proposed)
Class 3615.60 - Portable Electrical Equipment (Proposed)
Class 3615.70 - Electrical Unit Heaters (Proposed)
Class 3615.80 - Submersible Waste Water Pumps (Proposed)
Class 3615.90 - Electrically Operated Valves (Proposed)

NOTE: THESE CLASS NUMBERS ARE SUBJECT TO REVISION AS THE STANDARDS ARE ISSUED.

1.3 BASIS FOR FACTORY MUTUAL RESEARCH APPROVAL

See Approval Standard 3600, Paragraph 1.3.

1.4 BASIS FOR CONTINUED APPROVAL

See Approval Standard 3600, Paragraph 1.4.

1.5 BASIS FOR REQUIREMENTS

1.5.1 For general basis of requirements, See Approval Standard 3600, Paragraph 1.5.

1.5.2 The construction, tests, and markings required by this standard are equivalent and consistent with the intent of the following standard:

ANSI/UL 1203-1988 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

1.6 EFFECTIVE DATE

The effective date of an approval standard mandates that all products tested for approval after the effective date shall satisfy the requirements of that standard. Products Approved under a previous edition shall comply with the new version by the effective date or else forfeit approval. The effective date shall apply to the entire approval standard, or, where so indicated, only to specific paragraphs of the standard.

The effective date of this standard is JANUARY 1, 1992 for full compliance with all requirements.

1.7 SYSTEM OF UNITS

See Appendix A and Approval Standard 3600, Paragraph 1.7.

II DEFINITIONS

For purposes of this standard, the following terms apply:

EXPLOSIONPROOF - (as defined by the National Electrical Code, ANSI/NFPA-70) refers to equipment enclosed in a case which is capable of:

a) withstanding an internal explosion of a specified gas or vapor-in-air atmosphere;

b) preventing the ignition of a specified gas or vapor-in-air atmosphere surrounding the enclosure due to sparks, flashes or internal explosion; and

c) operating at temperatures which will not ignite the surrounding classified atmosphere.

NOTE: THIS TERM IS SYNONYMOUS WITH 'FLAMEPROOF ENCLOSURE' AS DEFINED BY THE INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) PUBLICATION 79-0.

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FLAMEPATH - The place where corresponding surfaces of two parts of an enclosure come together and prevent the transmission of an internal explosion to the atmosphere surrounding the enclosure.

GAP OF FLAMEPATH - refers to the distance between the corresponding surfaces at a joint measured perpendicular to the surfaces. For circular surfaces, this gap is defined as the difference between the two diameters (diametrical clearance).

LENGTH OF FLAMEPATH - The shortest path along a joint surface from the inside to the outside of an enclosure.

JOINT, FLAT/FLANGE - refers to a flamepath with a straight joint with parallel surfaces.

JOINT, SPIGOT - refers to a joint with two or more flamepaths at right angles to each other.

JOINT, THREADED - refers to the interface of internally and externally threaded components.

ROD, OPERATING - refers to a component normally of circular cross-section, used for transmitting control movements which may be rotary, linear, or a combination of both.

SHAFT - refers to a component, normally of circular cross-section, used for transmitting rotary motion.

VOLUME, INTERNAL FREE - refers to all the unfilled space in an explosionproof enclosure, with the normally installed parts in place.

III GENERAL REQUIREMENTS (OTHER THAN PERFORMANCE REQUIREMENTS)

3.1 MARKING INFORMATION

In addition to the marking information required in accordance with Factory Mutual Research Approval Standard Class 3600 "General Requirements", explosionproof electrical equipment shall be marked with the following information:

3.1.1 Precautionary Information - The words:

"TO PREVENT IGNITION OF HAZARDOUS ATMOSPHERES,
DO NOT REMOVE COVER WHILE CIRCUITS ARE LIVE"

or equivalent wording.

3.1.2 If the equipment was tested according to the EXCEPTION of Table 4, the label shall contain the statement:

"SEAL ALL CONDUITS WITHIN 18 INCHES"

or equivalent wording.

3.1.3 Equipment supplied with a factory-installed conduit seal shall be marked with the words:

"FACTORY SEALED, CONDUIT SEAL NOT REQUIRED"

or equivalent wording. This wording may be located on a paper sticker or removable tag located where it will be visible during installation.

3.1.4 Cover bolts intended to be tightened to a torque other than that specified by the bolt grade markings (reference Paragraph 3.3.9 A.), that torque shall be marked with the words:

"TORQUE COVER BOLTS TO ___ LB•FT (___ N•M) MAXIMUM"

or equivalent wording.

3.2 REQUIRED DOCUMENTATION FOR APPROVAL EXAMINATION

For the purposes of

(1) assessing compliance of equipment with Factory Mutual Research Approval requirements,

(2) determining what test samples will be required for the test and examination program, and

(3) providing a means for design modification control, the manufacturer shall submit documents which give a full and correct specification of the critical construction aspects of the equipment. One copy (except as noted) of the following documentation as it pertains to the Approval request should be assembled in an organized manner and submitted prior to scheduling of the test program. All documents shall identify the following:

- the manufacturer's name,
- document number or other form of reference number identification,
- title, and
- date of latest revision of document and/or the revision reference (i.e. number or letter indicating revision level).

NOTE 1: TEST PROGRAMS WILL BE SCHEDULED ONLY UPON RECEIPT OF ALL THE MATERIAL LISTED HEREIN.

NOTE 2: A SINGLE CERTIFICATION DRAWING MAY BE PROVIDED AS AN ALTERNATIVE TO PROVIDING SEPARATE PRODUCTION DRAWINGS. HOWEVER, THE CERTIFICATION DRAWING MUST CONTAIN ALL OF THE DETAIL REQUIRED OF PRODUCTION DRAWINGS.

NOTE 3: DRAWINGS IN A LANGUAGE OTHER THAN ENGLISH MAY REQUIRE PARTIAL TRANSLATION FOR USE IN AN APPROVAL PROGRAM.

- Marketing/Ordering Literature showing general specifications and functions of the equipment. These are generally very useful in determining project costs and may also be used as attachments to the final report for equipment approval projects. Typically, one copy will be sufficient at the beginning of a program but 15 copies may be necessary for use as report attachments at the conclusion of the program.

- Model Number Breakdown - An engineering drawing or sales specification sheet showing all model variations and options to be examined. Each model variation shall be uniquely identifiable by nameplate marking, or by distinctive model designation.

- Instruction Manual(s) providing installation, operation, and maintenance instructions.

- Quality Control Procedures document(s) detailing routine testing and final inspection procedures.

- Production Drawings

  - Electrical Schematic(s).
  - Final Assembly drawing and parts lists
  - Sub-assembly drawings or piece-part drawings/assembly drawings sufficient to detail primary circuit components, operator controls, enclosure design, and safety interlocks.
  - Casting, machining, and sub-assembly drawings as applicable to define all flameproof joints, wall thicknesses, materials, minimum acceptable joint tolerances, surface finish and flatness, coating or paint, conduit opening gaging requirements, potting materials, sealing materials, and gasket materials.

NOTE: IF A COMPONENT OR SUB-ASSEMBLY WHICH IS CRITICAL TO THE EXPLOSIONPROOF CHARACTERISTICS OF THE DEVICE BEING SUBMITTED IS MANUFACTURED BY AN OUTSIDE SUPPLIER, ALL OF THE PRECEDING DESIGN INFORMATION IS STILL REQUIRED. THAT SUPPLIER SHALL BE REQUIRED TO FORWARD DESIGN DRAWINGS TO FMRC, OR THE APPLICANT SHALL PREPARE SPECIFICATION DRAWINGS DETAILING THE INSPECTION LIMITS OF ACCEPTANCE ON FABRICATION TOLERANCES.

  - Protective Grounding Detail drawing(s) showing the method of protective grounding provided, including location, size, and marking.
  - Product label drawing(s) showing all required marking information. The label drawing should show proposed artwork indicating the manufacturer's name, address, model and serial numbers, equipment ratings, warning markings, and the FMRC Approval Mark.

- Documentation Control Specification showing proposed method of controlling documents which may be identified as Critical Documents by FMRC. These drawings will be identified by Factory Mutual Research at the conclusion of the Approval program. FMRC must be notified of changes to these documents via Form 797, "Approved Product Revision Report".

3.3 CONSTRUCTION REQUIREMENTS

3.3.1 ENCLOSURE MECHANICAL STRENGTH

Enclosure strength shall be sufficient to withstand the stresses resulting from internal explosions, hydrostatic overpressure tests, impact, and thermal shock. As a result of these tests, no damage or deformation shall occur that would weaken or jeopardize the explosionproof characteristics of the enclosure.

3.3.2 ENCLOSURE JOINTS

Flamepaths shall have a surface finish not rougher than 250 micro-inches when measured in accordance with ANSI B46.1 - Standard for Surface Texture.

3.3.3 FLAMEPATH DIMENSIONS

The subject of flamepath dimensions has been researched by various international agencies and is well documented. This research developed maximum experimental safe gap (MESG) dimensions for explosionproof enclosures which have been tried and proven over many years.

A tabulation of flamepath length and gap dimensions of various joint types versus enclosure volume is given as Appendix literature in this standard. The Appendix Tables have been derived from the International Electrotechnical Commission (IEC) October 1987 Draft Proposals to be published as Publication 79-1 "Electrical Apparatus for Explosive Gas Atmospheres".

The Appendix Tables or the additional margin of safety specified in this Section, yield a sufficient safety factor to assure confidence in the tested design for FMRC Approval. Factory Mutual Research Approval procedure is to enforce performance requirements versus design requirements wherever possible. Therefore, testing required by this standard is based on use of the tabulations as a guideline, as an alternative to requiring strict adherence to the table values in a product design. Designs not meeting this criteria shall be evaluated by the safety factor test methods specified for the type of joint design, according to the following paragraphs. Presented in this manner, a manufacturer can design a product using the Appendix Tables and anticipate passing the FMRC test program and other national and international test programs.

NOTE: NO ENCLOSURE SHALL BE CONSIDERED SATISFACTORY BASED ON MEETING THE APPENDIX VALUE ALONE, WITHOUT TESTING, AS FACTORS SUCH AS ENCLOSURE GEOMETRY, INTERNAL PARTS PROXIMITY TO FLAMEPATHS, PRESSURE PILING,

ENVIRONMENTAL SEAL GROOVES, ETC., HAVE AN EFFECT THAT CAN BE EVALUATED ONLY BY TESTING. THE INTENT OF THESE REQUIREMENTS IS TO INCORPORATE INTO THE DESIGN OF THE EQUIPMENT A DEFINED SAFETY FACTOR VERIFIED BY TESTS.

A. FLAT/FLANGE JOINTS

In addition to the ignition tests required by Paragraph 4.3, Safety Factor Ignition Tests according to Paragraph 4.4 shall be conducted if any of the following three conditions exist:

- The enclosure design maximum gap exceeds the gap specified for the flat/flange length values shown in the Appendix Tables; or,
- A maximum gap value is not shown in the Appendix Tables; or,
- The design flat/flange joint length falls below the minimum shown in the Appendix Tables.

SAFETY FACTOR TEST METHODS FOR FLAT/FLANGE JOINTS

- Flamepath Length Reduction to 75% of design minimum flat/flange length value; or
- Shimming to increase gap by 50% in excess of the design maximum gap; or
- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

B. SPIGOT JOINTS

In general, only the cylindrical portion of the joint is relied upon as a controlled flamepath. In addition to the ignition tests required by Paragraph 4.3, Safety Factor Ignition Tests according to Paragraph 4.4 shall be conducted if any of the following three conditions exist.

- The enclosure design maximum diametrical clearance exceeds the clearance specified for the cylindrical portion joint lengths shown in the Appendix Tables; or,
- A maximum diametrical clearance value is not shown in the Appendix Tables; or,
- The design minimum cylindrical portion joint lengths fall below the minimum shown in the Appendix Tables.

EXCEPTION: SPIGOT JOINTS HAVING A FLAT FLANGE PORTION GREATER THAN 0.25 INCH (6 mm) IN LENGTH AND AN INTERNAL CHAMFER LESS THAN 0.04 INCH (1 mm) MAY RELY ON BOTH THE CYLINDRICAL PORTION AND THE FLAT/FLANGE PORTIONS AS COMBINED FLAMEPATHS. IN SUCH CASES, THE MAXIMUM GAP OR DIAMETRICAL CLEARANCE OF ANY PORTION OF THE JOINT AND THE MINIMUM COMBINED FLAMEPATH LENGTH SHALL BE USED TO EVALUATE THE CONSTRUCTION IN THE SAME MANNER AS THE BASIC SPIGOT JOINTS DETAILED PREVIOUSLY.

SAFETY FACTOR TEST METHODS FOR SPIGOT JOINTS

- Flamepath Length Reduction to 75% of design minimum length; or
- Special Machining to increase diametrical clearance by 50% in excess of the design maximum diametrical clearance; or
- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

C. THREADED JOINTS

Threaded joints having fewer than the number of engaged threads and/or a class of fit other than that specified in the Appendix Tables shall be subjected to Safety Factor Ignition tests by either of the following most convenient methods.

NOTE: TAPERED THREADS THAT MEET THE GAUGING REQUIREMENTS FOR CONDUIT ARE NOT SUBJECTED TO SAFETY FACTOR IGNITION TESTING.

SAFETY FACTOR TEST METHODS FOR THREADED JOINTS

- Flamepath reduction by removing 30% of the effective thread engagement of the joint for Class 2 (6H/6g) or Class 3 fit; or by removing 50% of the effective thread engagement for a Class 1 fit (7H/8g); or
- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

D. CONDUIT OPENINGS (SUPPLY CONNECTIONS):

The enclosure shall be provided with means for connection to a recognized Class I, Division 1, wiring system.

1) Modified NPT (National Standard Pipe Taper) Openings (Suitable for Groups A, B, C, and D Locations) shall be provided in not smaller than 1/2 inch trade size and not larger than 4 inch trade size. Acceptable conduit openings must provide for a five full thread engagement with a minimum thread conduit or fitting. An opening meeting this requirement will have a deeper tapping than described in ANSI/ASME B1.20.1 "Pipe Threads, General Purpose (Inch)". Acceptable conduit openings will be within +1/2 to +3 1/2

turns deeper than nominal in lieu of the ±1 turn of nominal described in ANSI/ASME B1.20.1. A conduit stop, if provided, shall be smooth and rounded, having an inner diameter as specified in Table 1.

2) NPS (National Standard Pipe Straight) Conduit Openings (Suitable for Groups C and D) shall be provided in not smaller than 1/2 inch trade size and not larger than 4 inch trade size. Acceptable conduit openings must also provide an integral conduit stop at the inner end of the conduit opening. The conduit stop shall be smooth and rounded, having an inner diameter as specified in Table 1.

Table 1.

THROAT DIAMETER OF INTEGRAL CONDUIT STOP

TRADE SIZE OF CONDUIT OPENING in.	THROAT DIAMETER OF CONDUIT STOP Minimum in.	(mm)	Maximum in.	(mm)
1/2	0.560	(14.22)	0.622	(15.80)
3/4	0.742	(18.85)	0.824	(20.93)
1	0.944	(23.98)	1.049	(26.65)
1-1/4	1.242	(31.55)	1.380	(35.05)
1-1/2	1.449	(36.81)	1.610	(40.89)
2	1.860	(47.24)	2.067	(52.50)
2-1/2	2.222	(56.44)	2.469	(62.71)
3	2.761	(70.13)	3.068	(77.93)
3-1/2	3.193	(81.10)	3.548	(90.12)
4	3.623	(92.02)	4.026	(102.26)

3) Conduit openings not employing a conduit stop shall be smooth and well rounded at the interior end to reduce the likelihood of conductor insulation damage during installation.

4) All conduit openings, except those which must be used for installation, shall be supplied with metal plugs installed having at least five full threads engaged.

5) The enclosure wall thickness shall provide for at least five full threads of engagement with any conduit threaded per ANSI/ASME B1.20.1.

6) Conduit openings shall withstand the torque test specified in Paragraph 4.2.

E. ROTATING/RECIPROCATING SHAFT JOINTS WITH SLEEVE BEARINGS

In addition to the ignition tests required by Paragraph 4.3, Safety Factor Ignition Tests according to Paragraph 4.4 shall be conducted if any of the following three conditions exist.

- The design maximum diametrical clearance exceeds the clearance specified for the joint lengths shown in the Appendix Tables; or,

- A maximum diametrical clearance value is not shown in the Appendix Tables; or,

- The design minimum joint length falls below the minimum shown in the Appendix Tables.

SAFETY FACTOR TEST METHODS FOR SHAFT/ROD JOINTS

- Flamepath Reduction to 75% of design minimum length; or

- Special Machining to increase diametrical clearance by 50% in excess of the design maximum diametrical clearance; or

- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

F. ROTATING SHAFT JOINTS WITH BALL OR ROLLER BEARINGS (REQUIRED FOR SHAFTS ROTATING AT OVER 100 RPM)

In addition to the ignition tests required by Paragraph 4.3, Safety Factor Ignition Tests according to Paragraph 4.4 shall be conducted if any of the following three conditions exist.

- The design maximum diametrical clearance exceeds the clearance specified for the joint lengths shown in the Appendix Tables; or,

- A maximum diametrical clearance value is not shown in the Appendix Tables; or,

- The design minimum joint length falls below the minimum shown in the Appendix Tables.

SAFETY FACTOR TEST METHODS FOR ROTATING SHAFTS WITH BALL OR ROLLER BEARINGS

- Flamepath Reduction to 75% of design minimum length; or

- Special Machining to increase diametrical clearance by 50% in excess of the design maximum diametrical clearance; or

- Special Assembly to remove the bearings and wedge the shaft off center in the bore to maximize the diametrical clearance to a value that would approximate the 50% increase obtained by special machining; or

- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

G. FLAME ARRESTERS AND BREATHER/DRAINS

Flame arresters are required for air, gas, or liquid lines which enter electrical enclosures.

Drains are required on installation for process control equipment that depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system. (ref. NEC Section 501-5-f-3)

When provided as part of the equipment assembly; flame arrester, breather, and drain devices shall conform to the following requirements:

1) They shall be secured by staking, welding, peening, interference fit, or equivalent, to prevent inadvertent removal.

EXCEPTION: WHEN THE DEVICE IS CONSTRUCTED WITH A MALE NPT THREAD ACCORDING TO ANSI/ASME B1.20.1 "PIPE THREADS, GENERAL PURPOSE (INCH)" AND IS INSTALLED IN AN NPT CONDUIT OPENING.

2) Drains shall not require removal of any part of the fitting to drain liquid from the enclosure.

3) In addition to the ignition tests required by Paragraph 4.3 (conducted without the device installed to maximize pressure if the flame arrester could serve as a pressure vent), flame arresters shall be ignition tested by any of the following safety factor test methods.

SAFETY FACTOR TEST METHODS FOR FLAME ARRESTERS AND BREATHER/DRAINS

- Flamepath Reduction to 50% of effective flamepath; or
- Testing with a more sensitive gas by either of the methods described in Paragraph 4.4.

4) Breathers and drains may be independently Approved as an enclosure component by separate testing according to the requirements of Approval Standard 3615.10.

3.3.4 JOINT MATERIALS - NON-METALLIC ENCLOSURES

A. CHEMICAL COMPATIBILITY

Enclosure joint materials shall satisfy the requirements for chemical compatibility according to Approval Standard Class No. 3600.

B. FLAME RESISTANCE

Enclosure joint material must be undamaged by the ignition tests required according to Paragraph 4.3 and be flame resistant according to Paragraph 4.7.

3.3.5 GASKETS

A. GASKETS NOT RELIED UPON FOR EXPLOSIONPROOF PROTECTION

If a gasket of compressible or elastic material is used to seal a joint, e.g. to prevent the ingress of moisture or dust (including protection as Dust-Ignitionproof) or to prevent the leakage of a process fluid, etc., it shall be applied as a supplement to, and not be included in the flamepath portion of the joint.

The following characteristics of the joint shall be maintained:

- The prescribed gap and/or width of the joint with the gasket installed shall be unchanged from the dimensions without the gasket installed.

- The secureness of a threaded part or cover shall not be dependent upon the gasket (the gasket shall compress into a groove or chamfer such that the threaded part or cover bottoms the same with or without the gasket in place). Some alternatives to accomplish the required degree of secureness are mechanical cover-locking provisions, or close tolerance threads of covers to afford a friction fit. With these alternative constructions, the Paragraph 4.3 Ignition Tests are conducted with the threaded part or cover in the gasket seated position but without the gasket.

B. GASKETS RELIED UPON FOR EXPLOSIONPROOF PROTECTION

If a non-metallic gasket is used to cushion a lens, for example, it shall be considered a non-metallic enclosure material according to Paragraph 3.3.4.

A gasket constructed of polytetrafluorethylene or similar material shall be installed to reduce the likelihood of cold flow.

3.3.6 CEMENTS (I.E. SEALING ADHESIVES AND POURED SEALS)

Cements and Sealing adhesives for inspection windows, poured seals, etc. in explosionproof enclosures shall be considered a non-metallic enclosure material according to Paragraph 3.3.4.

EXCEPTION: FOR ADHESIVES THAT DO NOT INCREASE THE DESIGN GAP OF A FLAMEPATH, A FINAL INSPECTION PROCEDURE IS REQUIRED TO CHECK THAT THE ENCLOSURE GAP OF EACH PRODUCTION UNIT IS WITHIN DESIGN VALUES, THAT THE SEALING MATERIAL FILLS THE JOINT AS REQUIRED, AND THAT EXCESS MATERIAL IS REMOVED.

Adhesive materials are acceptable only for enclosure joints that are not intended to be disturbed during installation or repair.

The seal shall be of a material compatible with the insulation on any conductors passing through it;

The softening point of the seal material shall not be less than 200°F (93°C), nor less than the operating temperature conditions of the equipment; and,

The mechanical strength of a cemented joint or poured seal shall not rely entirely on the adhesive strength of a cement or adhesive material. Supplemental mechanical retention must be provided. The minimum length along a cemented joint, from inside to outside of the explosionproof enclosure shall be 0.24 in. (6 mm) for free internal volumes $\leq$6 in^3. (100 cm^3) or 0.39 in. (10 mm) for free internal volumes >6 in^3. (100 cm^3).

The thickness of a poured seal shall be at least equal to the inside diameter of the opening, but in no case be less than 5/8 in.(16 mm).

3.3.7 FLEXIBLE CORDS AND BUSHINGS

NOTE: FLEXIBLE CORDS ARE ONLY PERMITTED FOR PORTABLE LIGHTING EQUIPMENT, PORTABLE UTILIZATION EQUIPMENT, SUBMERSIBLE PUMPS, ETC. (REF. NEC 501-11)

Strain relief bushings for a flexible cord shall not be a flamepath. The cable entry shall be provided a poured seal according to Paragraph 3.3.6.

EXCEPTION: THE POWER CORD AND ALL ASSOCIATED STRAIN RELIEF BUSHING COMPONENTS THAT FORM A FLAMEPATH SHALL BE CONSIDERED NON-METALLIC ENCLOSURE MATERIALS ACCORDING TO PARAGRAPH 3.3.4.

3.3.8 MATERIALS APPLIED TO JOINT SURFACES FOR CORROSION PROTECTION

A. A corrosion-inhibiting grease may be applied to metal joint surfaces if it does not harden with age, does not contain an evaporating solvent, and does not cause corrosion of the joint surfaces. Compliance is determined by evaluation of the grease manufacturer's product specifications.

B. Metal joint surfaces may be plated by electro or chemical depositing methods. Plating thickness shall not exceed 0.00003 inch (0.008 mm). Hot dip plating methods are not acceptable.

C. Paints or sealing materials shall not be applied to joint surfaces.

EXCEPTION: A SEALING MATERIAL MAY BE APPLIED TO THE SURFACES OF JOINTS THAT ARE NOT INTENDED TO BE OPENED DURING INSTALLATION OR SERVICE OF THE EQUIPMENT. SUCH A SEALING MATERIAL MUST COMPLY WITH THE REQUIREMENTS FOR CEMENTS (REFERENCE PARAGRAPH 3.3.6).

EXCEPTION: A METALLIC PAINT OR OTHER CONDUCTIVE COATING MAY BE APPLIED TO THREADED FLAMEPATHS INCLUDING CONDUIT OPENINGS IF:

- THAT FLAMEPATH PREVENTS FLAME PROPAGATION WITH THE PAINT OR COATING IN PLACE;
- FIT CLASS REMAINS WITHIN SPECIFIED TOLERANCE;
- RESISTANCE ACROSS THE ASSEMBLED JOINT DOES NOT EXCEED 0.003 OHMS.

NOTE: THE RESISTANCE IS TO BE DETERMINED BY DIVIDING THE VOLTAGE DROP OBTAINED ACROSS THE JOINT BY 50 WHEN A 50 AMPERE AC OR DC CURRENT IS PASSED THROUGH THE JOINT.

3.3.9 JOINT SECURING FASTENERS

A. REMOVABLE FASTENERS

Removable fasteners are those used for securing covers or components to the enclosure and may be subject to removal during installation, operation, inspection, or maintenance of the equipment. Removable fasteners shall have the following characteristics:

- When removed, no hole exists through the enclosure wall; and,

EXCEPTION: BOLTS FOR COVER SECURING MAY PASS THROUGH THE ENCLOSURE WALL IF MINIMUM THREAD ENGAGEMENT REQUIREMENTS ARE MET.

- A minimum clearance of 1/2 the fastener nominal diameter between the fastener and the bottom of the tapped hole shall be provided. If cover bolts are provided with a washer, this requirement must be met with the washer removed;

- A minimum thickness around the fastener shall be of 1/3 the fastener nominal diameter or 1/8 inch (3.2 mm), whichever is greater;

- Bolts shall withstand the maximum specified torque for grade marking on the bolt head with no damage occurring to the bolt or the tapped hole threads.

EXCEPTION: FOR BOLTS THAT ARE TO BE TIGHTENED TO A LESSER TORQUE VALUE THAN SPECIFIED BY THE GRADE MARKING, THAT TORQUE MUST APPEAR ON THE EQUIPMENT LABEL PER PARAGRAPH 3.1.4.

B. NON-REMOVABLE FASTENERS

Non-Removable fasteners passing through the enclosure wall shall have the following characteristics:

- The fastener to enclosure wall joint shall comply with Section 3.3.4.; and,

- The fastener shall be secured by welding, staking, peening, or equivalent, to preclude inadvertent removal from the enclosure.

C. NAMEPLATE FASTENERS

Fasteners shall not penetrate an enclosure wall.

D. ROD AND SHAFT RETENTION

Provision shall be made for the securing of rods and shafts against inadvertent removal. The retaining means shall meet the requirements for enclosure materials. Retaining means relying solely upon set screws shall be redundant and each set screw alone shall provide the required degree of retention.

3.3.10 ENCLOSURE REQUIREMENTS FOR OUTDOOR CLASSIFIED LOCATIONS

Explosionproof enclosures rated for outdoor use shall also be evaluated in accordance with ANSI/NEMA - 250 "Enclosures for Electrical Equipment" with the following modification:

- Enclosure flamepaths shall be protected against corrosion, constructed of non-corrosive materials, or the effects of such corrosion shall be specifically addressed in the explosion testing.

3.3.11 ENERGIZED EXTERNAL PARTS

Any energized part of explosionproof equipment not protected by the explosionproof enclosure (for example, external sensor electrodes) shall be protected using the Intrinsic Safety Type of Protection per Factory Mutual Research Approval Standard Class 3610, or other applicable Type of Protection.

IV PERFORMANCE TESTS AND EVALUATION

4.1 GENERAL

4.1.1 This section describes the tests and required results to show equipment compliance to the requirements of Section III. Unless otherwise specified, all tests are conducted under prevailing laboratory conditions with respect to temperature, humidity, and atmospheric pressure.

4.1.2 SAMPLE PREPARATION

A. Equipment shall be ignition tested with normally installed internal components or equivalent dummy blocks in place. If the equipment is designed such that it can be used with all or part of the internal components removed, ignition tests shall be conducted such that the maximum ignition pressure is obtained. This may involve conducting ignition tests both with and without internal components in place.

B. Any potting compound employed, except that for factory installed seals, cemented joints, coil encapsulation or insulation, shall be removed for ignition tests.

C. Gaskets or seals provided in the enclosure joint surfaces only for outdoor or other environmental ratings shall be removed for ignition tests.

D. Samples submitted for ignition testing shall have flamepath gaps between 80% and 100% of maximum design values and flamepaths lengths within 100% to 120% of minimum design values. Samples submitted whose actual flamepath measurements fall outside of these values shall be modified to conform to these limits, or shall be subject to safety factor ignition tests based on maximum/minimum design values.

4.2 CONDUIT OPENING TORQUE TEST

4.2.1 Enclosure mechanical strength at conduit openings (reference Paragraph 3.3.3 D6) shall be verified by a conduit opening torque test. Damage to the enclosure resulting from the torque test shall not negate the explosion-proof properties of the enclosure. These properties shall be verified by inspection or by subsequent Ignition and Hydrostatic Tests according to Paragraph 4.3 and 4.5. Torque test values as a function of conduit trade size shall be according to Table 2.

4.2.2 Each conduit opening shall be fitted with a test plug/fitting torqued to the test value (Table 2). After torquing, the test plug/fitting shall be removed and the enclosure threads examined for compliance with Paragraph 4.2.1. Alternatively, the test plug/fitting(s) shall remain in place during the subsequent tests required, with no damage to the enclosure resulting to otherwise cause unsatisfactory test results.

Table 2.
CONDUIT TORQUE SPECIFICATIONS

Nominal Size of Conduit inches	Torque lb•ft	(N•m)
1/2, 3/4	67	(90)
1, 1-1/4 and 1-1/2	83	(113)
2, 2-1/2, 3, 3-1/2, 4	133	(181)

4.3 STANDARD IGNITION TESTS

These tests are designed to show that an enclosure, when installed in its normally assembled configuration is capable of a) withstanding an internal ignition of a specified atmosphere, and b) preventing ignition of the specified surrounding atmosphere.

A series of at least ten ignition tests shall be performed on each compartment. These tests shall use a representative gas for the gas group rating of the equipment, and varying mixtures as outlined in Table 3. Each independent compartment of the equipment enclosure shall be filled with and placed in an atmosphere of the appropriate gas mixture. The internal gas mixture shall then be ignited and internal pressure readings taken. Ignition for each test series shall be initiated at the location shown in Table 4.

Factory Installed Conduit Seals - Equipment having a factory installed seal shall be subjected to ignition and hydrostatic tests on each side of the seal. Conduit lengths as shown in Table 4 entitled "Compartments with Conduit Openings Non-Incendive Components* and Conduit ≤1 1/2 Inches" shall be used for tests on the conduit side of a seal. Ignition tests of the conduit side of a seal may be waived if the seal is satisfactorily tested at the hydrostatic pressures shown in Table 6.

Group A Equipment - Each series of ten tests conducted with the Group A test gas shall be preceded with one ignition of a 30% acetylene in air, by volume test mixture. This mixture produces a deposit of carbon particles which, when burning and expelled through the joints during the subsequent tests, shall not ignite the surrounding atmosphere.

Ignition Pressure Measurement - Ignition pressure shall be measured by suitable transducer(s) and recording instrumentation. A low-pass filter with a 3 db corner frequency at 5 kHz ±10% shall be used in the input to the recording instrumentation to limit the bandwidth.

High Ambient [Greater than 140°F (60°C)] - Electrical equipment rated for use in ambient temperatures greater than 140°F (60°C) shall also be subjected to ignition safety factor tests according to Paragraph 4.4 except conducted in an ambient temperature equal to the rated ambient plus 36°F (20°C).

The test results shall be considered satisfactory if:

- There is no ignition of surrounding atmosphere during any test;
- There is no visible permanent deformation of any part that is critical to the explosionproof characteristics of the equipment.

Table 3.
TEST MIXTURES

Group	Gas	Ignition Mixture Range % by Volume in Air
A	Acetylene	6.0-12.4
B	Hydrogen	22.6-38.2
C	Ethylene	4.4- 9.9
D	Propane	3.0- 6.5

Table 4.
SOURCE OF IGNITION

ENCLOSED ELECTRICAL EQUIPMENT LOCATION	GROUPS	IGNITION SOURCE FROM ENCLOSURE WALL
Compartment With Conduit Opening(s)		
Incendive *Electrical Components and/or Conduit Trade Size ≥ 2"	A, B, C, D	18 Inches (46 cm) or by arcing component
Non-Incendive *Electrical Components and Conduit ≤1-1/2"	A, B, C	5, 10, and 15 feet (1.5, 3, and 4.5 m)
	D	24 inches (61 cm)
EXCEPTION: DEVICES MAY BE TESTED WITH 18 INCHES (OR LESS) OF CONDUIT INSTALLED (TO SIMULATE ACTUAL INSTALLATION) IF THE EQUIPMENT LABEL CONTAINS THE APPROPRIATE LIMITATIONS ON SEAL FITTING INSTALLATION IN ACCORDANCE WITH PARAGRAPH 3.1.		
Compartment without Conduit Openings		
Any	A, B, C, D	Inside Compartment or at enclosure wall

* Reference Factory Mutual Research Approval Standard Class 3611 for categories of "Non-Incendive Electrical Equipment", a Non-Incendive Component is not capable of causing ignition under normal operating conditions.

4.4 SAFETY FACTOR IGNITION TEST METHODS

4.4.1 Flamepath modification as specified for the particular joint construction in Paragraph 3.3.3. The standard ignition tests are then performed on the modified sample only.

4.4.2 Testing with material representative of the next higher Group rating of the equipment.

Group D equipment may be safety factor tested by repeating ignition tests with the Group C test gas in addition to the standard ignition tests conducted with the Group D test gas.

Group C equipment may be safety factor tested by repeating ignition tests with the Group B test gas in addition to the standard ignition tests conducted with the Group C test gas.

Group A and B equipment may only be safety factor tested by the flamepath modification procedure.

4.4.3 Testing with enclosure and surrounding atmosphere pre-pressurized to greater than one atmosphere.

4.4.4 Testing with intentionally increased enclosure volume.

4.4.5 Testing with oxygen-enriched atmosphere.

4.5 HYDROSTATIC TESTS

A hydrostatic test shall be performed on each separate compartment after all ignition tests (Paragraphs 4.3 and 4.4) have been completed to verify a margin of safety over and above the maximum recorded ignition test pressures. The hydrostatic test pressure shall be in accordance with Paragraph 4.5.1. However, if the manufacturer performs a similar hydrostatic test on each unit as part of the quality control program, the hydrostatic test pressure shall be according to Paragraph 4.5.2. Gaskets and seals may be installed to minimize leakage during the test.

4.5.1 HYDROSTATIC TYPE TEST (STANDARD - NO ROUTINE TEST REQUIRED)

The hydrostatic test shall be conducted at a pressure equal to the highest ignition test pressure obtained from the Standard Ignition Tests (Paragraph 4.3) times the safety factor shown in Table 5. The pressure shall be applied gradually at a rate no less than 100 psi/min (690 kPa/min) and held for 1 minute at the required test pressure.

Table 5.

HYDROSTATIC TEST PRESSURE SAFETY MARGIN

Enclosure Material or part	Safety Margin	Compliance *
Metal Castings, non-metallic moldings	4	No visible permanent deformation
Fabricated Steel	2	No visible permanent deformation
Fabricated Steel	3	No rupture
Bolts	3	No visible elongation

* Visible permanent deformation may be permitted if the distortion does not affect the flameproof properties of the enclosure. Compliance is verified by inspection subsequent to the hydrostatic test or by repeating the ignition tests with satisfactory results.

Table 6.
(Ref. Paragraph 4.3)

HYDROSTATIC PRESSURES FOR FACTORY INSTALLED CONDUIT SEALS

Conduit Trade Size	Group A, B	Group C	Group D
1/2 thru 2-1/2	4 × Ign. Test Pres.	1200 psi (8300 kPa)	600 psi (4140 kPa)
3 thru 4	4 × Ign. Test Pres.	4 × Ign. Test Pres.	600 psi (4140 kPa)

4.5.2 HYDROSTATIC ROUTINE TEST (ALTERNATE)

If each unit is tested by the manufacturer as part of the routine quality control program, the hydrostatic test pressure (for any enclosure material or part) shall be:

A. 2 times the maximum recorded pressure developed in the ignition tests when the "pressure rise time" (Figure 1) is greater than 5 milliseconds, or

B. 3 times the maximum recorded pressure developed in the ignition tests when the "pressure rise time" (Figure 1) is 5 milliseconds or less.

The procedure of Paragraph 4.5.1 shall then be followed using these hydrostatic test pressures.

The manufacturer's routine hydrostatic test capability shall be demonstrated initially and subject to follow-up audit inspection.

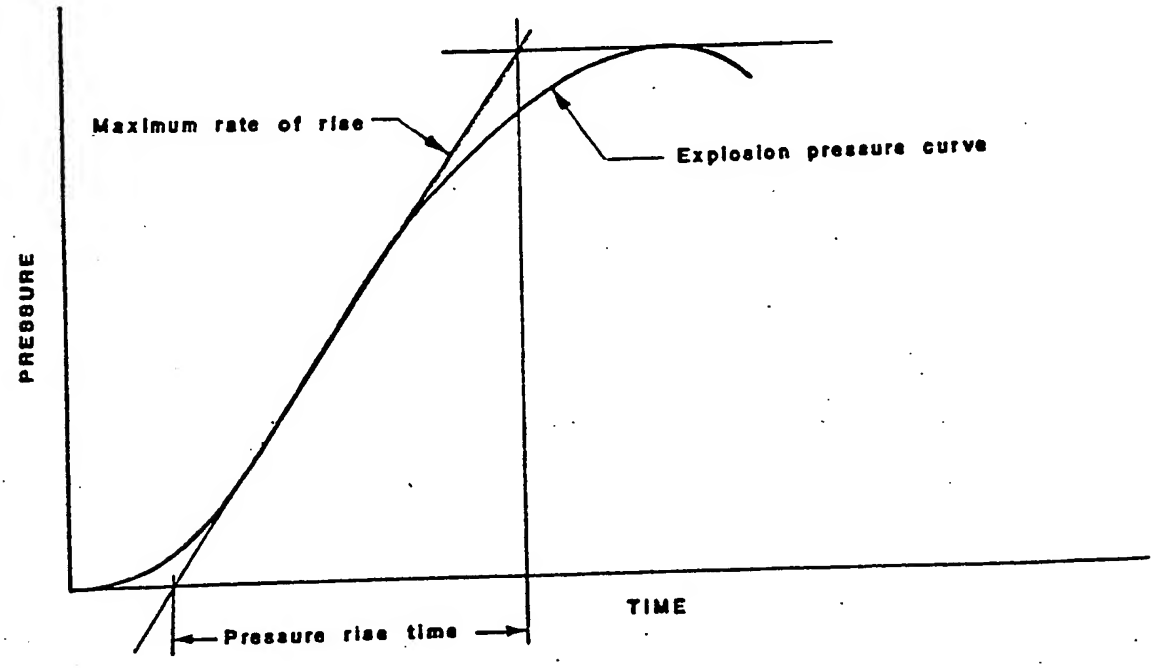


Figure 1. - Evaluation of Pressure Rise Time

4.6 IMPACT TEST

Impact tests shall be performed in accordance with Factory Mutual Research Approval Standard Class 3600 "General Requirements". The impact test results shall be considered satisfactory if there is no damage to the equipment such that it would not satisfactorily withstand the required ignition test (Paragraph 4.3). Non-impact tested parts may be used if necessary for hydrostatic tests (Paragraph 4.5).

4.7 FLAMMABILITY TEST

Non-metallic materials used in explosionproof electrical equipment according to Paragraph 3.3.4 shall not burn or support combustion for more than 1 minute when exposed to fire.

The flammability test shall be performed on all non-metallic parts that are critical to the explosionproof characteristics of the equipment.

The test shall be conducted in a draft free chamber. The test specimen shall be supported in a vertical position in the test chamber. The height of the natural gas flame of the burner shall be adjusted to 5 in. (12.7 cm) with an inner blue cone 1-1/2 in. (3.8 cm) high (Figure 2). The burner shall be tilted to an angle of 20 degrees from the vertical and the flame applied to the sample so that the tip of the inner blue cone of the flame touches the test specimen at the point approximately 6 in. (15.2 cm) above its lower end. The flame shall be brought up to the material in such a manner that the vertical plane containing the major axis of the burner tube will be at right angles to the plane of the material being tested (see Figure 2). The flame shall be applied for 15 seconds, and then removed for 15 seconds until 5 such applications have been made.

The test specimen shall be a sample at least 10 in. x 10 in. (254 x 254 mm) with a thickness not greater than the minimum thickness of the actual part. As an alternative, the actual part may be tested directly if its size is such that the test flame impinges only on a flat surface, not on edges, etc. that could otherwise affect the burning rate.

The test results shall be considered satisfactory if the material did not burn through and did not support combustion for more than one minute after the fifth application of the flame.

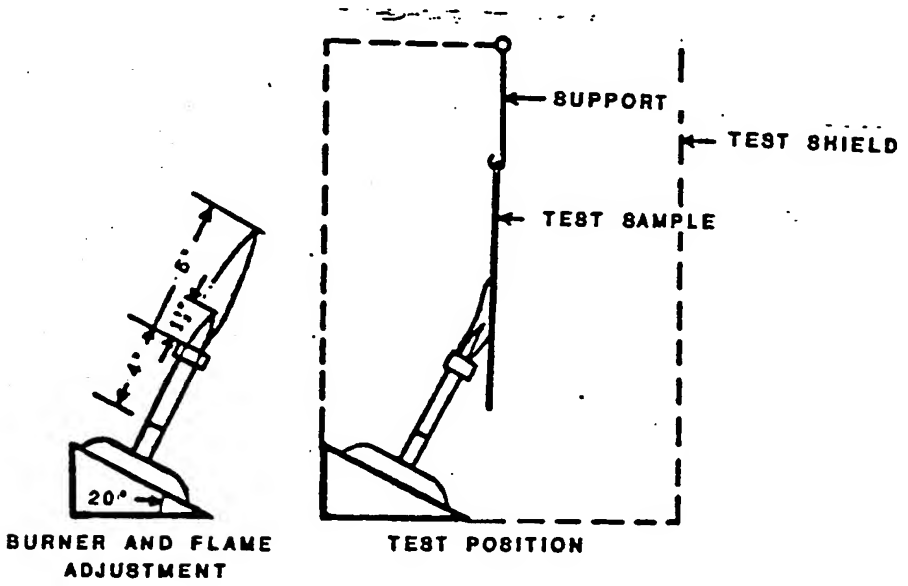


Figure 2. - Flammability Test Configuration

V OPERATIONS REQUIREMENTS

See Approval Standard 3600, Section VI.

VI REFERENCES

ANSI B46.1 - Standard for Surface Texture

ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (Inch)

ANSI/NFPA 70 - National Electrical Code

IEC Publication 79 - Electrical Apparatus for Explosive Gas Atmospheres

Factory Mutual Research Approval Standard Class Number 3600 - General Requirements for Electrical Equipment

Factory Mutual Research Approval Standard Class Number 3611 - Electrical Equipment for Use in Class I, Division 2; Class II, Division 2; and Class III, Divisions 1 and 2 Hazardous Locations

UNITS OF MEASUREMENT

LENGTH:	in. - "inches" (mm - "millimeters") mm = in. × 25.4
PRESSURE:	psi - "pounds per square inch" (kPa - "kilopascals") kPa = psi × 6.8948
TEMPERATURE:	°F - "degrees Fahrenheit" (°C - "degrees Celsius") °C = (°F - 32) × 5/9
TORQUE or MOMENT:	lb•ft - pound-feet" (N•m - "newton-meters") N•m = lb•ft × 1.356
FREQUENCY:	Hz - "hertz" (Also the SI unit)

GROUP D - MINIMUM WIDTHS/MAXIMUM GAPS

Metric (SI) Units

JOINT WIDTH (mm)	MAX GAPS(mm) FOR ENCL VOL (cm^3)		
TYPE OF JOINT	$\leq$ 100	100 < V $\leq$ 2000	V > 2000
FLANGE & SPIGOT			
6 $\leq$ L < 12.5	0.15	-	-
12.5 $\leq$ L < 25	0.15	0.15	0.10
25 $\leq$ L	0.20	0.20	0.20
SHAFTS AND RODS			
6 $\leq$ L < 12.5	0.15	-	-
12.5 $\leq$ L < 25	0.15	0.15	0.10
25 $\leq$ L < 40	0.20	0.20	0.20
40 $\leq$ L	0.25	0.25	0.25
SHAFTS WITH BALL / ROLLER BEARING			
6 $\leq$ L < 12.5	0.23	-	-
12.5 $\leq$ L < 25	0.25	0.23	0.15
25 $\leq$ L < 40	0.30	0.30	0.30
40 $\leq$ L	0.38	0.38	0.38

GROUP D - MINIMUM WIDTHS/MAXIMUM GAPS

U.S. Customary Units

JOINT WIDTH (in.)	MAX GAPS (in.) FOR ENCL VOL ($in.^3$)		
TYPE OF JOINT	≤ 6	$6 < V \leq 120$	$V > 120$
FLANGE & SPIGOT			
$0.25 \leq L < 0.50$	0.006	-	-
$0.50 \leq L < 1.00$	0.006	0.006	0.004
$1.00 \leq L$	0.008	0.008	0.008
SHAFTS AND RODS			
$0.25 \leq L < 0.50$	0.006	-	-
$0.50 \leq L < 1.00$	0.006	0.006	0.004
$1.00 \leq L < 1.57$	0.008	0.008	0.008
$1.57 \leq L$	0.010	0.010	0.010
SHAFTS WITH BALL / ROLLER BEARING			
$0.25 \leq L < 0.50$	0.009	-	-
$0.50 \leq L < 1.00$	0.010	0.009	0.006
$1.00 \leq L < 1.57$	0.012	0.012	0.012
$1.57 \leq L$	0.015	0.015	0.015

GROUP C - MINIMUM WIDTHS/MAXIMUM GAPS

Metric (SI) Units

JOINT WIDTH (mm)	MAX GAPS(mm) FOR ENCL VOL (cm^3)		
TYPE OF JOINT	$\leq$ 100	100 < V $\leq$ 2000	V > 2000
FLANGE & SPIGOT			
6 $\leq$ L < 12.5	0.10	-	-
12.5 $\leq$ L < 25	0.10	0.10	0.08
25 $\leq$ L	0.10	0.10	0.10
SHAFTS AND RODS			
6 $\leq$ L < 12.5	0.10	-	-
12.5 $\leq$ L < 25	0.10	0.10	0.08
25 $\leq$ L < 40	0.15	0.13	0.10
40 $\leq$ L	0.20	0.15	0.13
SHAFTS WITH BALL / ROLLER BEARING			
6 $\leq$ L < 12.5	0.15	-	-
12.5 $\leq$ L < 25	0.20	0.15	0.10
25 $\leq$ L < 40	0.23	0.20	0.15
40 $\leq$ L	0.30	0.23	0.20

GROUP C - MINIMUM WIDTHS/MAXIMUM GAPS

U.S. Customary Units

JOINT WIDTH (in.)	MAX GAPS (in.) FOR ENCL VOL ($in.^3$)		
TYPE OF JOINT	≤ 6	$6 < V \leq 122$	$V > 122$
FLANGE & SPIGOT			
$0.25 \leq L < 0.50$	0.004	-	-
$0.50 \leq L < 1.00$	0.004	0.004	0.003
$1.00 \leq L$	0.004	0.004	0.004
SHAFTS AND RODS			
$0.25 \leq L < 0.50$	0.004	-	-
$0.50 \leq L < 1.00$	0.004	0.004	0.003
$1.00 \leq L < 1.57$	0.006	0.005	0.004
$1.57 \leq L$	0.008	0.006	0.005
SHAFTS WITH BALL / ROLLER BEARING			
$0.25 \leq L < 0.50$	0.006	-	-
$0.50 \leq L < 1.00$	0.008	0.006	0.004
$1.00 \leq L < 1.57$	0.009	0.008	0.006
$1.57 \leq L$	0.012	0.009	0.008

GROUP B - MINIMUM WIDTHS/MAXIMUM GAPS

Metric (SI) Units

JOINT WIDTH (mm)	MAXIMUM GAPS (mm) FOR ENCLOSURE VOLUMES (cm^3)				
TYPE OF JOINT	≤ 100	$100 < V \leq 500$	$500 < V \leq 1500$	$1500 < V \leq 2000$	$2000 < V \leq 6000$
FLANGE					
$6 \leq W < 9.5$	0.05	-	-	-	-
$9.5 \leq W < 15.8$	0.05	0.05	-	-	-
$15.8 \leq W < 25$	0.05	0.05	-	-	-
$25 \leq W$	0.05	0.05	-	-	-
SPIGOT					
$6 \leq L < 12.5$	0.05	0.05	-	-	-
$12.5 \leq L < 25$	0.08	0.08	0.08	0.08	-
$25 \leq L < 40$	0.08	0.08	0.08	0.08	0.08
$40 \leq L$	0.10	0.10	0.10	0.10	0.10
SHAFTS AND RODS					
$6 \leq L < 9.5$	0.05	-	-	-	-
$9.5 \leq L < 12.5$	0.05	0.05	-	-	-
$12.5 \leq L < 25$	0.08	0.08	0.08	0.08	-
$25 \leq L < 40$	0.08	0.08	0.08	0.08	0.08
$40 \leq L$	0.10	0.10	0.10	0.10	0.10
SHAFTS WITH BALL / ROLLER BEARING					
$6 \leq L < 9.5$	0.08	-	-	-	-
$9.5 \leq L < 12.5$	0.08	0.08	-	-	-
$12.5 \leq L < 25$	0.13	0.13	0.13	0.13	-
$25 \leq L < 40$	0.13	0.13	0.13	0.13	0.13
$40 \leq L$	0.15	0.15	0.15	0.15	0.15

GROUP B - MINIMUM WIDTHS/MAXIMUM GAPS

U.S. Customary Units

JOINT WIDTH (in.)	MAXIMUM GAPS (in.) FOR ENCLOSURE VOLUMES ($in.^3$)				
TYPE OF JOINT	≤ 6	$6 < V \leq 30$	$30 < V \leq 90$	$90 < V \leq 122$	$122 < V \leq 360$
FLANGE					
$0.25 \leq W < 0.38$	0.002	-	-	-	-
$0.38 \leq W < 0.63$	0.002	0.002	-	-	-
$0.63 \leq W < 1.00$	0.002	0.002	0.001	-	-
$1.00 \leq W$	0.002	0.002	0.001	0.001	0.001
SPIGOT					
$0.25 \leq L < 0.50$	0.002	0.002	-	-	-
$0.50 \leq L < 1.00$	0.003	0.003	0.003	0.003	-
$1.00 \leq L < 1.57$	0.003	0.003	0.003	0.003	0.003
$1.57 \leq L$	0.004	0.004	0.004	0.004	0.004
SHAFTS AND RODS					
$0.25 \leq L < 0.38$	0.002	-	-	-	-
$0.38 \leq L < 0.50$	0.002	0.002	-	-	-
$0.50 \leq L < 1.00$	0.003	0.003	0.003	0.003	-
$1.00 \leq L < 1.57$	0.003	0.003	0.003	0.003	0.003
$1.57 \leq L$	0.004	0.004	0.004	0.004	0.004
SHAFTS WITH BALL / ROLLER BEARING					
$0.25 \leq L < 0.38$	0.003	-	-	-	-
$0.38 \leq L < 0.50$	0.003	0.003	-	-	-
$0.50 \leq L < 1.00$	0.005	0.005	0.005	0.005	-
$1.00 \leq L < 1.57$	0.005	0.005	0.005	0.005	0.005
$1.57 \leq L$	0.006	0.006	0.006	0.006	0.006

GROUP A - MINIMUM WIDTHS/MAXIMUM GAPS

Metric (SI) Units

JOINT WIDTH (mm)	MAXIMUM GAPS (mm) FOR ENCLOSURE VOLUMES (cm^3)				
TYPE OF JOINT	≤ 100	$100 < V \leq 500$	$500 < V \leq 1500$	$1500 < V \leq 2000$	$2000 < V \leq 6000$
FLANGE					
$6 \leq W < 9.5$	-	-	-	-	-
$9.5 \leq W < 15.8$	0.02	0.02	-	-	-
$15.8 \leq W < 25$	0.02	0.02	0.02	-	-
$25 \leq W$	0.02	0.02	0.02	0.02	0.02
SPIGOT					
$6 \leq L < 12.5$	0.05	0.05	-	-	-
$12.5 \leq L < 25$	0.08	0.08	0.08	0.08	-
$25 \leq L < 40$	0.08	0.08	0.08	0.08	0.08
$40 \leq L$	0.10	0.10	0.10	0.10	0.10
SHAFTS AND RODS					
$6 \leq L < 9.5$	0.05	-	-	-	-
$9.5 \leq L < 12.5$	0.05	0.05	-	-	-
$12.5 \leq L < 25$	0.08	0.08	0.08	0.08	-
$25 \leq L < 40$	0.08	0.08	0.08	0.08	0.08
$40 \leq L$	0.10	0.10	0.10	0.10	0.10
SHAFTS WITH BALL / ROLLER BEARING					
$6 \leq L < 9.5$	0.08	-	-	-	-
$9.5 \leq L < 12.5$	0.08	0.08	-	-	-
$12.5 \leq L < 25$	0.13	0.13	0.13	0.13	-
$25 \leq L < 40$	0.13	0.13	0.13	0.13	0.13
$40 \leq L$	0.15	0.15	0.15	0.15	0.15

GROUP A - MINIMUM WIDTHS/MAXIMUM GAPS

U.S. Customary Units

JOINT WIDTH (in.)	MAXIMUM GAPS (in.) FOR ENCLOSURE VOLUMES ($in.^3$)				
TYPE OF JOINT	≤ 6	$6 < V \leq 30$	$30 < V \leq 90$	$90 < V \leq 122$	$122 < V \leq 360$
FLANGE					
$0.25 \leq W < 0.38$	-	-	-	-	-
$0.38 \leq W < 0.63$	.0008	0.0008	-	-	-
$0.63 \leq W < 1.00$	.0008	0.0008	0.0008	-	-
$1.00 \leq W$	.0008	0.0008	0.0008	0.0008	0.0008
SPIGOT					
$0.25 \leq L < 0.50$	0.002	0.002	-	-	-
$0.50 \leq L < 1.00$	0.003	0.003	0.003	0.003	-
$1.00 \leq L < 1.57$	0.003	0.003	0.003	0.003	0.003
$1.57 \leq L$	0.004	0.004	0.004	0.004	0.004
SHAFTS AND RODS					
$0.25 \leq L < 0.38$	0.002	-	-	-	-
$0.38 \leq L < 0.50$	0.002	0.002	-	-	-
$0.50 \leq L < 1.00$	0.003	0.003	0.003	0.003	-
$1.00 \leq L < 1.57$	0.003	0.003	0.003	0.003	0.003
$1.57 \leq L$	0.004	0.004	0.004	0.004	0.004
SHAFTS WITH BALL / ROLLER BEARING					
$0.25 \leq L < 0.38$	0.003	-	-	-	-
$0.38 \leq L < 0.50$	0.003	0.003	-	-	-
$0.50 \leq L < 1.00$	0.005	0.005	0.005	0.005	-
$1.00 \leq L < 1.57$	0.005	0.005	0.005	0.005	0.005
$1.57 \leq L$	0.006	0.006	0.006	0.006	0.006

THREADED JOINTS

Groups A, B, C and D

1. Thread pitch for both tapered and parallel threads shall shall not be finer than that shown in the following Table.

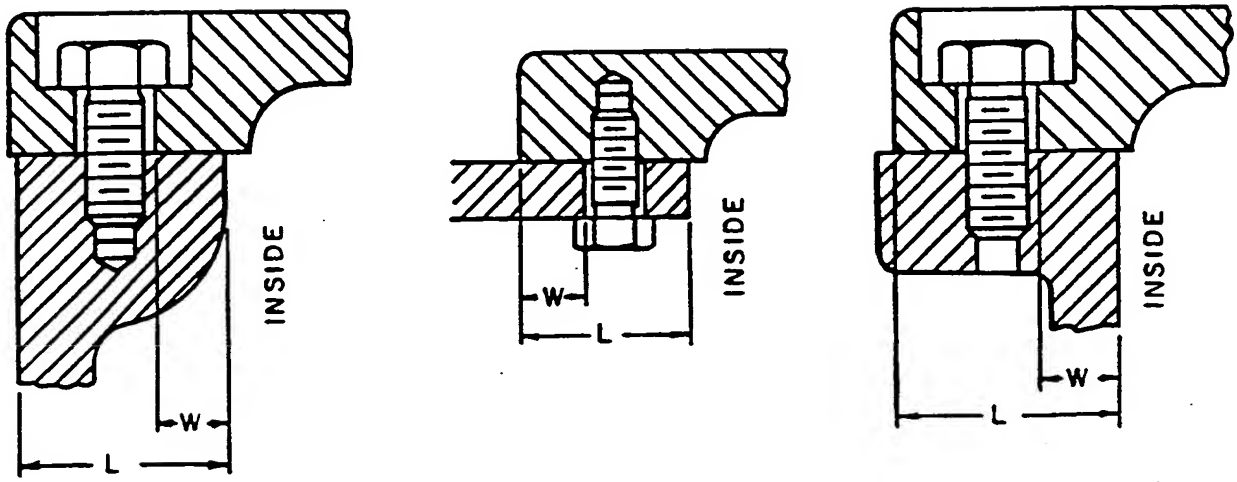
2. Taper threads shall engage 5 full threads minimum.

3. Parallel (straight) thread engagement shall conform to the following:

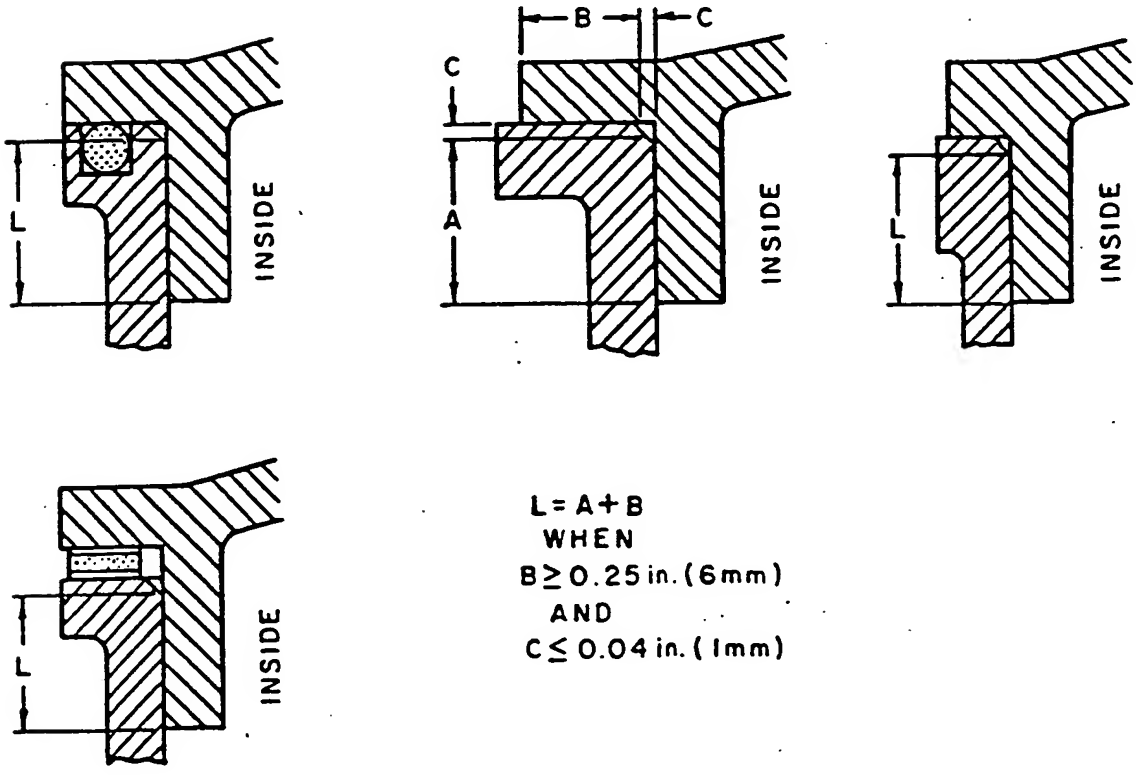
GAS GROUP	PERMITTED THREAD PITCH	MINIMUM THREAD ENGAGEMENT		
		FIT CLASS		
		3 (5H/4h)	2 (6H/6g)	1 (7H/8g)
A	≤ 20 thds/in. (≥ 1.27 mm/thd)	6	7	8
B	≤ 20 thds/in. (≥ 1.27 mm/thd)	5	6	7
C & D	≤ 32 thds/in. (≥ 0.79 mm/thd)	5	5	5

FLAMEPATH MEASUREMENTS A, B, C, D

FLAT/FLANGE JOINTS



SPIGOT JOINTS



$L = A + B$
WHEN
$B \geq 0.25$ in. (6mm)
AND
$C \leq 0.04$ in. (1mm)

SHAFT/ROD-SLEEVE/BEARING JOINTS